Aviation Research

teacher guide

Activity I: Flight Delays

lesson overview

Materials: Part A: web access OR copies of student sheets. Part B: computers with web access OR copies of Air Travel Consumer Reports, copies of student sheets. Part C: Materials from local travel agent, commercial airline web sites, local airports on arrivals and departures for one day. Part D: Data about delay for specific airlines, related to time in the day, from the previous exercise OR teacher can estimate these times and supply them to the student.

Time for set-up: Part A: none. Part B: less than 5 minutes. Part C: Only for finding materials. Part D: none

Time for lesson: Part A: 10 minutes or more. Part B: 2 hours or more, depending on steps; varies. Part C: If material is readily available, about 1 hour. Part D: 30 - 60 minutes

Student Prerequisites: Part A: knowledge of air travel experiences, Eng, SS. Part B: ability to read charts, add & subtract percentages, calculate percentages, create charts and graphs. Part C: ability to construct line graphs (if given points), ability to analyze line graphs, to look for trends, understanding of basic probability, ability to estimate the equations of curves and lines (of varying types) to fit graphs. Part D: Understanding of d = rt and ability to graph points, at minimum. At maximum, vector manipulation.

Icons for recommended subject areas where activities could be used:

Parts A and B: PRE, A1, STAT, Basic Science (lab reports), SS, EN
Part C: PRE, A1, A2, TRIG, STAT, SS, ENG
Part D: PRE, A1, GEO (if using vectors), A2 (with extensions), SS, ENG

Objectives: Part A: Warm-Up for other Navigation Activities involving delay.
Part B: Students will practice:

* using components of a lab report
* collecting data from a web source
* using and calculating percentages
* students will calculate basic statistical parameters
* students will learn how to use a spreadsheet program
* students will create a logical argument
* Students will create and analyze charts and graphs
* students will collaborate to obtain / analyze large data sets
* students will compare data statistically

Part D: Students determine when a connecting flight is a better choice than a direct flight, and vice versa, based on delay information with regards to duration, time of day, etc.

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Student Assessments: Writing (done on worksheet or in essay form), discussion. Data in form of chart and graphs, prose describing how data can be misinterpreted, filled-in worksheets, work to show algebra.

Link to Standards Matrix:

* represent data in various graphical forms including scatter plots
* creating lines of best fit, which may be lines, curves, logarithmic or trigonometric functions, parabolas, etc.
* using basic statistics, probability
* analyzing statistical analysis to look for possible misconceptions
* d = rt, various rate problems (including work rate and cost)
* distance formula, Pythagorean theorem, or estimating distance by measuring
* plotting points on a coordinate graph
* vector analysis (magnitude) and addition
* analysis of charts (and potentially graphs, using maxima and minima, intersection, etc.) to reach a conclusion

Activity I: Flight Delays

Introduction

The **Aviation Research** activity begins by investigating one of the main problems with the commercial aviation industry today: delay frequency. **Part A - Picking A Route to Take** introduces the concept in a warm-up fashion, involving students building on their own knowledge bases. As soon as it is realized that delay is a major factor contributing to the perception of a commercial airline, the second activity, **Part B - Delays andAirport Usage, Time of Year, Time of Day**, addresses delay. In this activity, delay data is accumulated from an internet database and is used to paint a graphical and mathematical picture of how delay is related to the frequency of airport use, time of year, and time of day. Extensions can also be made to compare delay with weather. **Part C - Delays and Time of Day and Airlines**, is an alternate activity to Part B. In Part C, commercial airlines are investigated on a local level across a short period of time. Data is collected by the students, and is analyzed in similar ways to Part B. However, the different nature of the sample types and sizes in B and C should lead students to very different methods of statistical analysis, if the extension to statistics were made. **Part D - Delay and Fuel Use** provides a glimpse into how delays influence the airline industry itself, in terms of cost to operate airplanes and increased fuel use.

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Part A - Picking a Route to Take

Pilots like to be able to choose their own routes of travel. Years ago, when flying was still relatively new, this was an option, but now that skies are packed with airplanes, pilots have little choice in the route they may take to get from one place to another. Despite the fact that a flight might take more time and use more fuel, controllers will force pilots to follow standardized routes of travel. If we watched airplanes for long enough (or better yet, recorded a day's worth of flights coming and going from an airport, and played it back at high speed), it would be easy to see the limited numbers of paths an airplane can take within a certain region.

Commercial airlines know their routes so well that they can print maps in the backs of airline magazines showing the anticipated routes for most flights. Maps are also published showing these standard routes of travel, which pilots use for planning.

Still, controllers may need to change these routes slightly, based on ground and weather conditions and traffic in any particular region.

1. As a consumer, what are the major factors to consider, when picking a route to take or an airline for travel?

   Brainstorm - some possible answers: time of year (anticipating delays, airline history(number of accidents, type of snacks, number of flights flown since when?), time of day for travel, where you are going - are there direct route or connection route options?, cost, availability, time for flight, delay history…

   _____

   _____

   _____

   _____

   _____

   _____

2. Most often, the top influencing factor in picking an airline is past experience (positive or negative) with the airline. What positive or negative experiences have you had with airlines? Discuss and create a list of pros and cons. Are there people in your classwho can recount good experiences with an airline that far outweigh the bad experiences someone else might have had?

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3. The one thing that makes trips hard, time and time again, are delays. Delays can be due to a variety of factors. What do you think could cause a delay?

Students might mention frequency of use (number of people that must fly is too high, number of airplanes is too high, number of available airplanes is too low), mechanical problems, air traffic congestion, weather, carryover from other flights (airplane left previous location too late).

Part B - Delays and airport usage, time of year, time of day

It is easy to get a sense of frequency of use of a specific region, based on the top ten commercial airlines (which account for about 90 percent of the commercial airline revenues) and most frequently used airports in the US. You will be obtaining data to fill in the following chart. Before you start, make some hypotheses about the information you obtain.

Hypothesis:

- The frequency of flights coming into an airport IS / IS NOT proportional to the frequency of delays.
- The airport with the highest percentage of delays will be _____.
- The airport with the highest number of delays will be _____.
- The month with the highest number of delays will be _____. (for comparison with other groups' data)
- The time of day with the highest number of delays will be _____.

1. Visit www.dot.gov/airconsumer/atcr99.htm to obtain information a monthly Air Travel Consumer Report from 1999. Fill in the following chart to help you determine which airports have the highest frequency of flights arriving / departing and the highest frequency of delays, and furthermore if the frequency of delays is related to the frequency of flights.

   www.dot.gov/airconsumer will provide more options about reports, if you are looking for other years, like 2000.

   These reports are quite extensive, so it is recommended that you advise students not to print them in their entirety; rather they should cut and paste portions to a text-compiling application (MSWord or SimpleText), then print OR take notes on information that is relevant.

   Students will need to do some processing of the data in the reports. For instance, the reports provide information on non-delayed arrivals. Students will need to subtract to get delayed arrivals. They will also need to convert a percent delayed to a number delayed using manipulation of percents. The teacher may decide to notify the students of this or let them try to figure it out on their own.

   Teacher can have students create the above chart in a spreadsheet program like MSExcel, to teach them new technology skills and aid them in calculating percentages.

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Name: Date:

Airport Delays Worksheet

Air Travel Consumer Report used: _____ (month), _____ (year)

Airport	Number of Arrivals	% Delayed	Number Delayed	Hour of the Day with most Delays (mil. time)
Atlanta	21985	32.3	7101	21
Boston	8574	38.6	3310	19
Baltimore	6533	31.5	2058	6
Cleveland	10308	32	3299	19
Cincinnati	6630	29.7	1969	22
Washington DC	6811	34.3	2336	18
Denver	11297	26.5	2994	21
Dallas Fort Worth	20458	24.5	5012	22
Detroit	12772	39	4981	21
EWR	10335	38.9	4020	18
Houston	10633	21.3	2265	23
John F Kennedy	3625	29.4	1066	18
Las Vegas	10115	27.5	27.82	23
Los Angelels	15411	28.2	4346	22
Laguardia	7956	37.4	2976	19

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Name: Date:

Airport Delays Worksheet				
Air Travel Consumer Report used: _____ (month), _____ (year)				
Airport	**Number of Arrivals**	**% Delayed**	**Number Delayed**	**Hour of the Day with most Delays (mil. time)**
Orlando	8260	32.1	2652	17
Miami	5571	29.2	1627	20
MSP	11295	31.3	3535	18
ORL	24538	45.2	11091	20
Portland	4642	29.2	1356	20
Philadelphia	9626	42.1	4053	20
Phoenix	14821	26.6	3942	18
Pittsburgh	8700	41.3	3593	21
San Diego	5496	30.8	1693	21
Seattle	7725	36.2	2797	21
San Francisco	11207	39	4371	12
Salt Lake City	6999	24.6	1722	21
St. Louis	14667	40.1	5882	21
TPA	4923	35.3	1738	20

2. Now graph your information as a bar graph, with airports along the x axis, and one of the four column headings along the y-axis.

   The teacher may decide to limit the number of graphs done or the data used in each graph. The goal is for the students to be able to reassess their hypotheses and be able to share data in a new graphical representation which is easy to digest, with other groups, so that students can see trends across time and postulate why those trends might occur (due to weather, holidays, historic events (strikes), or so on).

3. Calculate means, standard deviations, and medians for the data.

4. Now that you have this information, make conclusions about your hypotheses. Explain the conclusion, based on the hypothesis and how it was obtained. Use a summative graph to clearly show a summary of information that defends the conclusion. Describe other research that could be done to better investigate delays. What are two additional questions that could be interesting to research answers to?

5. Based on the data you have, can you determine the likelihood of a delay with respect to the different regions? If you were a traveler, which regions would you avoid? To answer these questions, you might do:
   - correlation tables
   - regressions
   - chi squared tests
   - t-tests

   Students can extend their investigation to include weather, as weather is the number one cause of flight delays. Have students use www.ncdc.noaa.gov/ol/climate/stationlocator.html to collect weather information for months and times, in the city where their airports are.

   Students could also expand their investigation to include location of airport (latitude, longitude) and delay information.

Part C - Delays and Time of Day and Airlines

This activity is somewhat similarto the last one, but offers insight into specific airlines and more local information. It can be used in conjunction with the previous activity to better investigate delays per airline, as now information is organized per airline and actual duration of delays is provided. It would be interesting for a statistics class to compare this to the last study, because the last study has significantly larger data sets, though certain statistical parameters are not mentioned, which, in study #2, the student can account for. Study #2 is meant to be done for a local airport, in the hopes that students will have more insights into why delays occur when they do and possible solutions.

A particularly user-friendly site is that for the Austin-Bergstrom International Airport (Texas) at www.abia.org/mufids/arrivals.asp This site posts real-time information showing original schedules and if arrivals are on time or delayed, and if they are delayed, when they occurred.

Other sites require you to enter flight information (flight numbers, airlines, departure airports, arrival airports), so students will have to obtain this information first. If they know this information, they can easily use Airwise to locate information about many of the most popular commercial airlines. www.airwise.com OR http://travel.airwise.com/arrivals/index.html provides information categorized by airport or airline.

If the students can't find flight numbers anywhere, they can visit the Auckland Airport site and obtain information for flights to of from Auckland, New Zealand. Then they can use this information to find real time flight information using Airwise. The Auckland International Airport site is www.auckland-airport.co.nz/cgi-bin/

Delays typically become more common as the day goes on. This is why people often consider the time of day when making reservations.

1. Using data from airlines (each group should get their own), fill in the following table for at least 2 flights per hour for one 24-hour day.

Use the following definitions for variables a through d:

a = Scheduled departure
b = Actual departure
c = Scheduled Arrival
d = Actual Arrival

Determine a minus b and c minus d in minutes. The difference should be negative if the flight was late or positive if the flight was early.

Off Schedule Times

Name: Date:

Airline:					Data for Date:			
Hour	**a - b**	**c - d**	**Hour**	**a - b**	**c - d**	**Hour**	**a - b**	**c - d**
0			8			16		
0			8			16		
1			9			17		
1			9			17		
2			10			18		
2			10			18		
3			11			19		
3			11			19		
4			12			20		
4			12			20		
5			13			21		
5			13			21		
6			14			22		
6			14			22		
7			15			23		
7			15			23		
Other Time		**a - b**	**c - d**		**Other Time**		**a - b**	**c - d**

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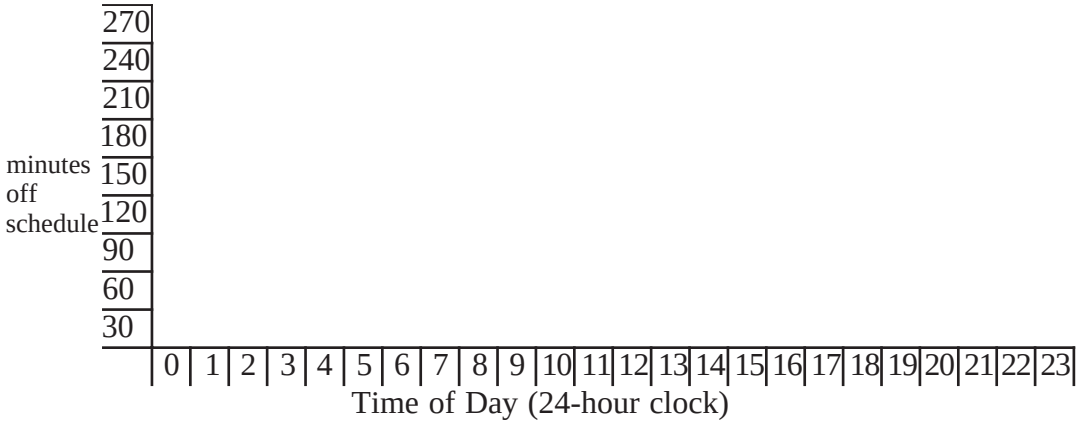
2. Now plot "off schedule" times versus time of day on the following line graph. Have all other groups do the same.

Draw a line (it doesn't have to be straight) for each set of data, to show the trends.

You could build the trend line a number of ways. You could build it so that:

- the same number of points are above and below the line.
- the line passes through the average of the two values for any hour.
- other (ask your teacher): _____



If there appears to be a trend for all airlines, draw a summative graph on another piece of paper. Be sure to document calculation of average values, which you use for constructing your graph.

3. Can you approximate an equation for measuring delay with respect to the time of day?
   a) using a line
   b) using a parabola
   c) using a trigonometric function
   d) using a logarithmic function
   e) using regression (linear or not)

4. What is the probability that a delay (any delay) will occur at each of the hours of operation (typically 6 am - 11 pm)?

5. Which airline is the most delayed? Based on what you see about delays, decide how you can rank the commercial airlines.

   a) Describe how you could rank the airlines, so that results are misleading.

   Here is where it will be important for students to realize that not all airlines are created equal! Students should avoid using percentage, as the variation in total flights for an airline is tremendous. Operating time also may come into play, as not all airlines operate at all times. In addition, students may be tempted to ask "Is where the airplane is coming from and/or how long it has been in air significant?" Depending on method of analysis, the answer may be "yes" or "no."

   b) Describe how you could rank them so results are not as misleading, and defend the validity of your data. Rank them and make a conclusion for the question: which commercial airline is most delayed?

6. Do #5 again for the following question: Which airline has the highest probability of being delayed?

Part D - Delay and Fuel Use

The cost of a flight is related to the time the airplane is in use and the fuel consumed. Passengers often have a choice between flight options:

a) a direct flight between A and B, and
b) a connecting flight between A, C, and B.

Use examples to help explain this - some students may not understand why there are options for direct or connecting flights. You might ask:

- *When given an option between connecting and direct flights, what factors would you consider, when making your decision?*

Students might bring up delay, times of flights, duration of flights, potential layover, extra places you may have to go (where layover will be), cost of flight, type of airplane (larger airplanes are usually more comfortable than smaller ones)…

- *What are some examples of flights where you would get a choice between direct and connecting?*

Students will tell you that longer flights are more likely to have connections. Also rarer or less popular flights probably go somewhere else first, after which you may have to hop on a very small airplane to finish the flight.

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The following problems use delay time information from the previous activity. If you do not have this information, talk to your teacher about getting a printout of the information. This information is available on the teacher's pages. The numbers in the following problems are not based on actual operational costs, as these vary widely in different circumstances. These numbers are provided for illustration only.

For the following points A, B, and C, and following flight times, what is the actual time of the airplane in air and hence the cost to operate it, if the airplane travels 500 miles / hour and costs $5000/ hour to operate?

Before presenting these problems to your classroom, you may want to discuss specific equations to use, or steps to go through. Students may get frustrated with the units involved in these problems - you could use this frustration to discuss different kinds of rates and their units. Most students will know d = rt, and be able to indicate rates of car speed, based on experience. Students are recommended to work out the following problems by following these steps.:

1. *Determine distance by one of the following methods, and place it in the appropriate blank.*
   - *a) determining the magnitude of vectors, then adding them*
   - *b) using the distance formula*
   - *c) drawing points below on a piece of graph paper, then creating right triangles and calculating the diagonals (distance) using the Pythagorean Theorem.*
   - *d) drawing the points below on a piece of graph paper, then using a ruler or other measuring device, whose scale is one mile = one unit on graph paper to estimate distance.*

2. *Determine the time to fly, using d = rt (rate is given above), and put it in the chart.*

3. *Calculate the average amount of delay for the time at which you are flying, and put this in the chart.*
   - *This could be simple. Tell students to use only the staring time (e.g. 7am) to determine delay.*
   - *This could be complicated. Tell students to use an average of the delay times for every hour during which the airplane will be operating, to determine delay time.*

4. *Add the times together and fill in the total time blank in the chart*

5. *Use the equation c = rt, where c = cost and r = rate in terms of $ / hour and t = total time, to determine the cost of the flight.*

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1. Situation 1:
   A = (3, 2) B = (25, 14) C = (25, 5)

Distance travelled:

Direct Flight: _____

Connection Flight: _____

Departure Time	Flight Duration	Extra Time for Average Delay	TOTAL Time in Air	Cost
7:00 am				
12:00 noon				
2:00 pm				
5:00 pm				
8:00 pm				

2. Situation 2:
   A = (-2, 5) B = (12, 14) C = (7, 7)

Distance travelled:

Direct Flight: _____

Connection Flight: _____

Departure Time	Flight Duration	Extra Time for Average Delay	TOTAL Time in Air	Cost
7:00 am				
12:00 noon				
2:00 pm				
5:00 pm				
8:00 pm				

3. Situation 3:
A = (3, 1) B = (15, -4) C = (10, -6)

Distance travelled:

Direct Flight: _____

Connection Flight: _____

Departure Time	Flight Duration	Extra Time for Average Delay	TOTAL Time in Air	Cost
7:00 am				
12:00 noon				
2:00 pm				
5:00 pm				
8:00 pm				

4. In general, when would you consider taking a connecting flight rather than a direct flight, in order to have the quickest flight possible?

Students should note that there are a variety of factors here. They could tell you they would consider taking a connecting flight when (a) distance of the flight is long, (b) flight leaves at certain time of day, or (c) the delay average is a certain duration. This is a perfect moment to ask students to tell you HOW long is "long?" They could create a graph from which it would be easy to see how length of flight or delay is related to amount of delay or amount of time in air.

Students might also mention other factors not mentioned in this activity - influence of airflow (wind) in speeding or slowing airplanes (see the weather section!), frequency of flights in various regions (so average delay for an hour may be a combination of horrendous delays and insignificant delays).

5. Is there a commercial airline that appears to have less of a problem with delay? If so, explain which one and some factors that might contribute to this.

This could lead into an interesting research project or debate regarding different commercial airlines. Here are a couple of other project ideas if teachers want to expand this project:

- *Students play the part of the FAA, which monitors aircraft performance and creates new policies and regulations regarding air traffic. The teacher, as head of FAA, has told student groups, who are part of her "cabinet," to come up with a new set of policies about delay. Students must research a new policy which may decrease delay, and present their policy and defend it, in from of the cabinet.*

- *Each student group represents a specific commercial airline. Students must create a multimedia presentation where they will advertise their airline, specifically talking about its history, specialties, finances, crash ratings, delay record, etc. You could up the ante by having a prize - students are volleying for a contract with a major business which needs a commercial airline to ship their products or people frequently. You could up the ante another way by saying the teacher and audience are FAA review board members who will be dismissing airlines, based on traffic and crash records. Student groups must adequately defend their airlines, or face eternal dismissal.*

- *Students can research other issues in the commercial airline industry and present papers or topics for further discussion of the bureaucracy involved in this commercial system.*